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Soil Burial Tests:

Effect of Soil Burial Exposure on the Properties of Molded Plastics

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An evaluation of the effect of soil burial on a wide variety of thermoplastic and thermoset plastic molding compounds has been completed for specimens interred eight years at the soil burial test plots in Georgia and New Mexico. In general, the effect of soil environment has been mild on most of the molded plastics. The most significant changes occur to those materials most sensitive to moisture. These changes take place independently of either burial site or depth of soil burial (6 and 18 inches).

I. INTRODUCTION

The molded plastics selected for soil burial tests represented a limited cross section of those commercially available at the time the program was started. Many of the materials evaluated are now being used in diverse telephone apparatus, including telephone sets, terminals, relays, covers, switches, connectors, underwater repeaters, and many other applications. It can be anticipated, as buried plant becomes more common, that many of these materials will be considered for underground applications.

Any plastic used in a buried telephone plant system would represent a long-time investment and a minimum life expectancy of twenty years is not an unusual requirement. Therefore, before any applications are developed for employing plastics underground, it is necessary to assess the general effect of soil burial on the different plastics that are commercially available. Most molded plastics are synthetic organic compounds and subject to normal aging processes such as oxidation or hydrolysis. Continuous exposure to any of the overall complex soil environments, whether they are physical, chemical, or biological, may increase the rate at which these plastics age. Earlier studies have led

to a greater understanding of why some materials fail in certain environments while others do not.

II. CHEMISTRY OF MOLDED PLASTIC COMPOUNDS

The chemistry of the molded plastics covered in this paper has been described adequately in most standard polymer textbooks. Three such books are listed in the references.[1-3]

2.1 *Base Polymers*

2.1.1 *Thermoplastic Compounds*

We have chosen twenty-six thermoplastics representing ten basic materials for soil burial exposure. Table I lists those materials selected

TABLE I—THERMOPLASTIC MOLDING COMPOUNDS FOR SOIL BURIAL

Butyrate, Black Butyrate, Clear Propionate, Black	*Cellulose Compounds*
Polystyrene, GP, Clear Styrene Acrylonitrile Copolymer, Natural Acrylonitrile-Butadiene-Styrene, Natural Acrylonitrile-Butadiene-Styrene, Black	*Styrene Compounds*
Nylon, Type 610, Natural Nylon, Type 6, Natural	*Polyamides*
Poly (methyl methacrylate), Clear	*Acrylic*
Polyethylene H. D., Black Polypropylene, Ivory Ethylene-ethyl-acrylate, Natural Ethylene-vinyl-acetate, Natural	*Polyolefin Compounds*
PVC, Semirigid, Gray PVC, Rigid, Dark Cray PVC, Rigid, Sheet, Cray	*Poly(vinyl chloride) Compounds*
Acetal, Homopolymer, Natural Acetal, Homopolymer, Black Acetal, Copolymer, Natural	*Acetals*
Polychlorotrifluorethylene, Natural Polytetrafluorethylene, Natural	*Fluorocarbon Polymers*
Polycarbonate, Natural Polysulfone, Natural	*Bisphenol A Polymers*
Polyurethane, Natural	*Polyurethane Molding Compound*
Polyphenylene Oxide, Beige	*Poly-(2, 6-dimehyl-1, 4-phenylene oxide)*

TABLE II—THERMOSET MOLDING COMPOUNDS FOR SOIL BURIAL

Phenolplastic Two Stage Wood-Flour, Black Phenolplastic One Stage Wood-Flour, Black Phenolplastic Two Stage Asbestos, Black Phenolplastic Two Stage Mineral, Black	*Phenolic Compounds*
DAP, Orlon, Green DAP, Mineral, Gray	*Diallyl Phthalate Compounds*
Melamine, Glass, Natural	*Melamine*
Styrene-Polyester, Glass Bulk Molding Compound	*Styrene-Polyester*
Alkyd, Glass, Sheet	*Alkyd*
Styrene-Butadiene, Crosslinked Silica Filled, Gray	*Crosslinked Styrene-Butadiene*

and identifies the thermoplastics that make up each group. Of course, as new and promising materials are developed, they are added to the program. The materials selected to date vary greatly in their mechanical and electrical properties and in their ability to resist moisture.

2.1.2 *Thermoset Compounds*

We have included ten compounds representative of six basic thermosetting materials for soil burial testing. These compounds are listed in Table II. Although thermoset compounds, like the thermoplastic compounds, have similar electrical and mechanical properties, one important difference is that thermoset compounds must contain reinforcing fillers in order to achieve their optimum characteristics.

2.2 *Additives, Reinforcing, Fillers, Plasticizers, etc.*

In addition to fillers, however, most plastic molding compounds contain other ingredients. Many contain an antioxidant to protect the material against oxidation either in processing or in service and thereby improve the resistance to aging. Lubricants are sometimes used to improve processing conditions or to facilitate molding. In some cases, plasticizers are added to impart flexibility or to soften the polymer for processing. There are also special additives used for specific purposes such as colorants, flame retarders, and ultraviolet absorbers. These substances may be present in quite high proportions which may substantially alter the physical properties of the basic

plastic material. In addition to these additives, thermoset molding compounds use various types of filler to enhance their properties and characteristics. Roughly half of the compound is made up of filler. This allows a wide latitude of electrical and mechanical properties, depending on the type of filler used.

2.3 *Commercial Compounds*

In most cases, the commercial molded plastics selected for soil burial tests contain some or all of the additives mentioned above. These are proprietary compounds and the additives are not often disclosed. The types of fillers used in the thermoset compounds are generally known, but the amounts and types of chemical additives are not. However, the purpose of the soil burial program on molded plastics was not to evaluate the performance of a specific filler or additive, but to determine the relative resistance of a group of commercial plastic materials to a soil environment.

III. TEST METHODS

The effect of soil burial on the various molded plastics was primarily followed by quantitatively observing the changes in their mechanical and electrical properties. Qualitative visual examinations were also noted for any changes in the general appearance that could indicate a deterioration of the plastic.

3.1 *Types of Mechanical and Electrical Tests*

The effect of soil burial on molded plastics was followed by changes in the mechanical and the dc insulation resistance properties. Samples were removed from the soil test plot after 1, 2, 4, and 8 years of exposure. All exhumed specimens were conditioned for six months at 23°C and 50 percent relative humidity. Each group of molded plastics was examined for changes in tensile, hardness, and electrical properties after each soil exposure period. In addition to these tests, flexural properties were also recorded for the thermoset compounds. The tensile properties include tensile strength, yield, modulus, and ultimate elongation and were determined in accordance with the general procedures of ASTM D638. Flexural strength and modulus were determined for the more rigid thermoset compounds using ASTM D790. Hardness tests were performed according to ASTM D785. Several indentation scales were needed to cover the entire range of molded plastic materials. The dc electrical insulation resistance measurements

were made on all materials using the flat end of the 8-1/2 inch test bar with the prescribed terminal distance. This is not the shape of specimen called for in ASTM D257, but it has yielded comparative data in the soil burial program.

3.2 *Basis for Selection*

The mechanical properties of the molded plastics selected for soil burial vary over a wide range from soft and flexible to hard and brittle, with many intermediate combinations. It was, therefore, difficult in some cases to select standard tests for the measurement of a particular property which would be suitable for all materials. However, because we have had some understanding of the nature of most of these plastics, and their behavior under conditions of stress, we chose a group of tests to accomplish the following:

(*i*) Assess the initial differences among the plastics and establish a control value.
(*ii*) Measure the effect of soil burial on all materials.
(*iii*) Provide guidelines useful to design engineers.

All of these tests are useful for following the parameters of a large group of materials whose properties vary widely.

3.3 *Preconditioning*

One very important consideration is the moisture content of the specimen at the time of testing. Ideally, it would be desirable to perform the tests directly in the field at the time the samples are unearthed. This would indicate their actual mechanical characteristics under soil conditions. However, this procedure is impractical. Another possibility is to test the exposed samples immediately upon their return to the laboratories. However, their moisture content would depend on the length of time in transit from the burial site. Very often a number of weeks elapse before the specimens are finally made available for testing. Consequently, it was decided to condition the exposed samples for six months at 23°C and 50 percent relative humidity to bring the specimens back to a moisture content reasonably comparable to that of the initial samples. Essentially, the data then measured would be the permanent changes that have occurred in the molded plastics as a result of soil burial. There are a sufficient number of control specimens of each material in storage to determine whether any changes in mechanical properties are actually the results of soil burial or of natural aging. Most of the materials are relatively stable at room conditions

TABLE III—TENSILE BREAK STRENGTH OF THERMOPLASTICS (PERCENT CHANGE AFTER SOIL BURIAL)

Material	Location	Topsoil				Subsoil			
		1 Yr	2 Yrs	4 Yrs	8 Yrs	1 Yr	2 Yrs	4 Yrs	8 Yrs
Cellulose Acetate Butyrate, Black	Georgia	+23	+22	+41	+50	+14	+11	+30	+50
	New Mexico		+26	+49			+21	+47	
Cellulose Propionate, Black	Georgia	+30	+9	+32	+38	+22	+10	+35	+40
	New Mexico		+13	+36			+14	+37	
Cellulose Acetate Butyrate, Clear	Georgia	+16	+11	+36	+46	+2	+5	+27	+41
	New Mexico		+21	+42			+19	+37	
Polystyrene, General Purpose, Clear	Georia	NC	−7	NC	NC	NC	−9	NC	+3
	New Mexico		−1	−2			−1	−1	
Styrene-Acrylonitrile Copolymer, Natural	Georgia	NC	−3	NC	NC	−3	−4	NC	NC
	New Mexico		+1	−1			−1	−3	
Acrylonitrile-Butadiene-Styrene, Natural	Georgia	−6	−12	−1	−1	−12	−15	−3	NC
	New Mexico		−1	−9			−6	−5	
Acrylonitrile-Butadiene-Styrene, Black	Georgia	−2	−2	+2	+1	−2	−3	+2	+5
	New Mexico		NC	NC			NC	−1	
Acetal, Homopolymer, Natural	Georgia	NC	−1	−3	NC	NC	+3	+3	NC
	New Mexico		NC	−3			NC	−3	
Acetal, Copolymer, Natural	Georgia	−2	−1	NC		−2	+2	−1	
	New Mexico	−1	−2			−5	+2		
Acetal, Homopolymer, Black	Georgia	+1	NC	−4	+2	+2	−1	−3	+1
	New Mexico		−1	−3			NC	−2	

NC = No change

TABLE IV—TENSILE BREAK STRENGTH OF THERMOSET PLASTICS (PERCENT CHANGE AFTER SOIL BURIAL)

Material	Location	Topsoil				Subsoil			
		1 Yr	2 Yrs	4 Yrs	8 yrs	1 Yr	2 Yrs	4 Yrs	8 Yrs
Phenolic 2/s Wood-Flour, Black	Georgia	−20	+29	+36	+21	−10	+20	+32	+20
	New Mexico		+34	+33			+22	+43	
Phenolic 1/s Wood-Flour, Black	Georgia	−31	−15	+9	+2	−14	−10	−3	+9
	New Mexico		+7	−3			−1	−8	
Phenolic 2/s Asbestos, Black	Georgia	−15	+8	+28	−2	−31	−5	+26	+15
	New Mexico		+14	+13			+11	+12	
Phenolic 2/s Mineral, Black	Georgia	−8	+7	+1	+2	NC	+9	+3	+11
	New Mexico		+13	+4			+22	+4	
DAP, Orlon, Green	Georgia	−26	−9	−5	−11	−27	−17	+9	−6
	New Mexico		+8	+8			−2	+1	
DAP, Mineral, Gray	Georgia	−2	−1	+7	+1	−9	+9	+11	+1
	New Mexico		+8	+1			−2	+1	
Styrene-Butadiene, Crosslinked, Silica	Georgia	+35	+23	+27		+37	+30	+26	
	New Mexico	+33	+28	+33		+36	+30	+37	

NC = No change

and therefore no deterioration in mechanical properties is anticipated for the reference specimens over a period of many years.

IV. RESULTS

4.1 *Effect of Soil Test Plot Site and Depth of Burial*

Tables III and IV clearly show that neither the variations in the soil conditions nor the depth at which the specimens are buried is critical. Individual materials exhibit similar behavior at each location and at each burial level. Since this has been the case for all of the examination periods, it was evident that the only way to handle the massive amount of data was to make a composite of all the information for a given exposure period and take the average for the individual types of plastic compounds. Consequently, we have taken the results of each test from each location and burial level and have combined them for each basic group of common materials listed in Tables I and II. The results of all of the tests correlate quite well and the average change is entered as either a percent increase or a percent decrease for the mechanical properties and as orders of magnitude of change for the insulation resistance measurements. Thus we have reduced the total number of tables necessary for data display without adversely affecting the value of the information obtained.

4.2 *Thermoplastic Changes*

Significant changes in the tensile strength at break for thermoplastic compounds are limited to those that are sensitive to moisture. These include the cellulosic molding resins and the type 6 polyamide (nylon) compound. Figure 1 shows the results of cellulose compounds buried 1, 2, 4, and 8 years and includes both the cellulose acetate butyrate and cellulose propionate compounds. Both materials have changed substantially from their original values, indicating their instability in a soil system.

Type 6 nylon deteriorates steadily in tensile properties. This material has changed from a hard, tough thermoplastic to such a rigid, brittle material that rupture occurs before any appreciable elongation (Fig. 2) can take place. Type 610 nylon showed much superior resistance properties than type 6 nylon. Type 610 nylon absorbs 75 percent less moisture than nylon 6.

After eight years of soil burial the semirigid poly (vinyl chloride) compound has generally increased in hardness and tensile strength and diminished in extensibility. In every testing period there were

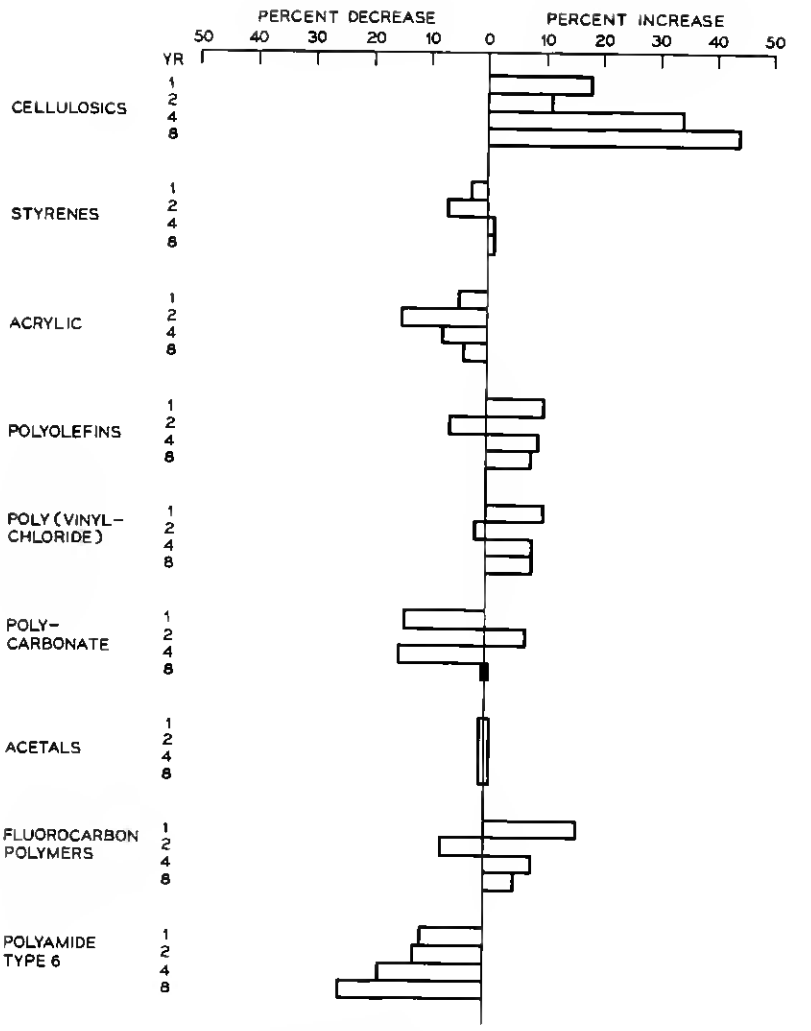

Fig. 1.—Changes in tensile break strength for thermoplastics.

some signs of microbiological action on the surface of the plasticized PVC test specimens. This consisted of mainly black greasy surface deposits which were not totally removed by the cleaning method employed.

4.3 *Unchanged Thermoplastics*

The effects of soil burial on the tensile and hardness properties of the other thermoplastics shown in Figs. 1, 2, and 3 are quite mild.

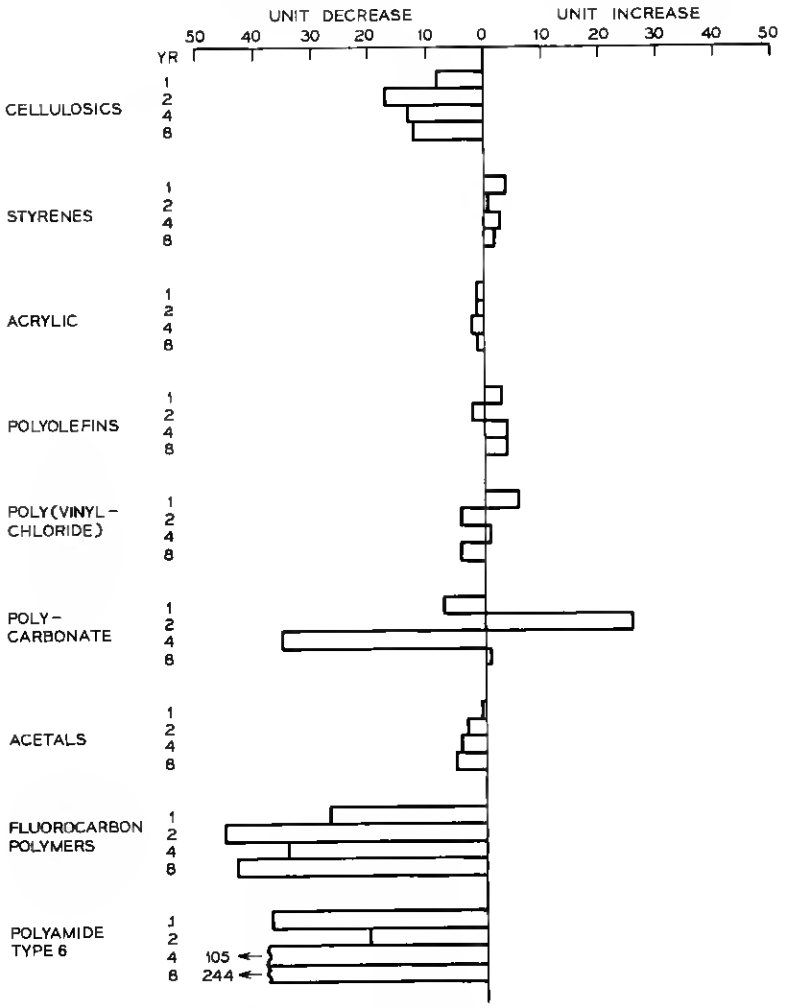

Fig. 2—Changes in ultimate elongation of thermoplastics.

In most cases there are small changes in property values from year to year, but these are generally considered to be within experimental error. For this reason, judgment is required in evaluating differences in test data to make certain a valid difference exists. Some errors are associated with the test method itself, while others may arise through defects in test specimens. Anomalous behavior is especially evident

for the ultimate elongation results of polycarbonate and fluorocarbon polymers shown in Fig. 2. While changes in elongation for polycarbonate vary from negative to positive, the fluorocarbon polymers show a continuous loss. Since these results do not correlate with those of other mechanical tests, we can only conclude that a real change has not occurred.

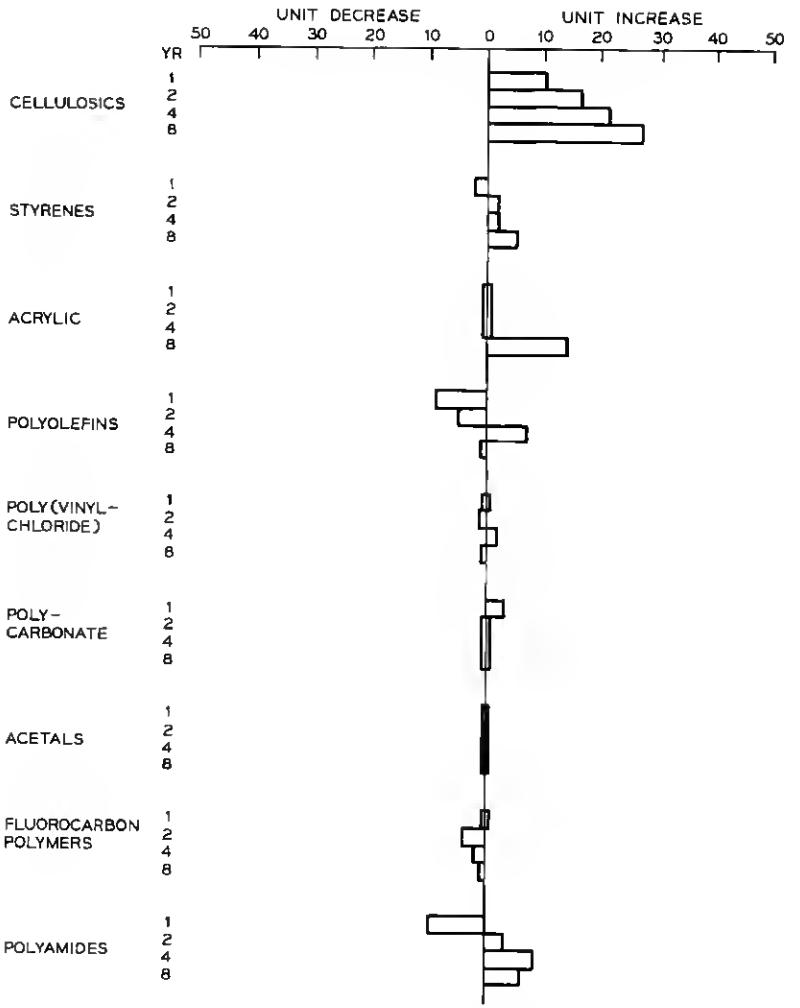

Fig. 3—Changes in hardness for thermoplastics.

The remaining thermoplastic compounds that do not show any significant change at this time are the styrene group, the polyolefins, the two rigid poly (vinyl chloride) compounds, and the acetal homopolymer. The individual materials that compose each group are given in Table I.

4.4 *Late Starting Thermoplastics*

Several variations of commercial molding plastics, as well as compounds based on new polymers, have been developed since the burial program was first initiated. In 1965 we selected six new compounds: a natural color acetal copolymer, a beige polyphenylene oxide compound, a natural color thermoplastic polyurethane molding compound, a natural polysulfone resin, and two natural color polyethylene copolymers–ethylene-ethyl acrylate and ethylene-vinyl-acetate.

These materials have been in the program for four years and have been tested for the effects of soil burial for 1, 2, and 4 years. None of the mechanical or electrical properties of these materials has changed significantly. For example, Table III clearly shows that the tensile strength at break for the natural acetal copolymer has not changed during 1, 2, and 4 years of soil burial.

4.5 *Thermoset Changes*

The effects of soil burial on the mechanical properties of thermoset molding compounds are shown in Figs. 4 thru 7. Tensile strength and modulus data shown in Fig. 4 indicate there have been some significant changes in these properties during the first four exposure periods. This is also true for the flexural properties shown in Figs. 5 and 6, but not for the hardness values given in Fig. 7.

The individual compounds that constitute the thermoset groups are given in Table II. Of all the thermoset compounds, soil burial had the least effect on the mechanical properties of the diallyl phthalate compounds. One of these materials has a mineral filler while the other depends on a synthetic fiber filler for impact strength. The phenolic compounds show a slight to moderate effect. A significant difference was noted in the phenolic compounds containing wood-flour and those using asbestos or mineral filler. For instance, wood-flour-filled phenolics show a greater loss in tensile strength at break than those having mineral or asbestos as a filler. However, in flexural properties, just the opposite appears to be the case where the mineral and asbestos compounds have shown the greatest change. The slight decrease in hardness shown in Fig. 7 is further evidence that a soil environment

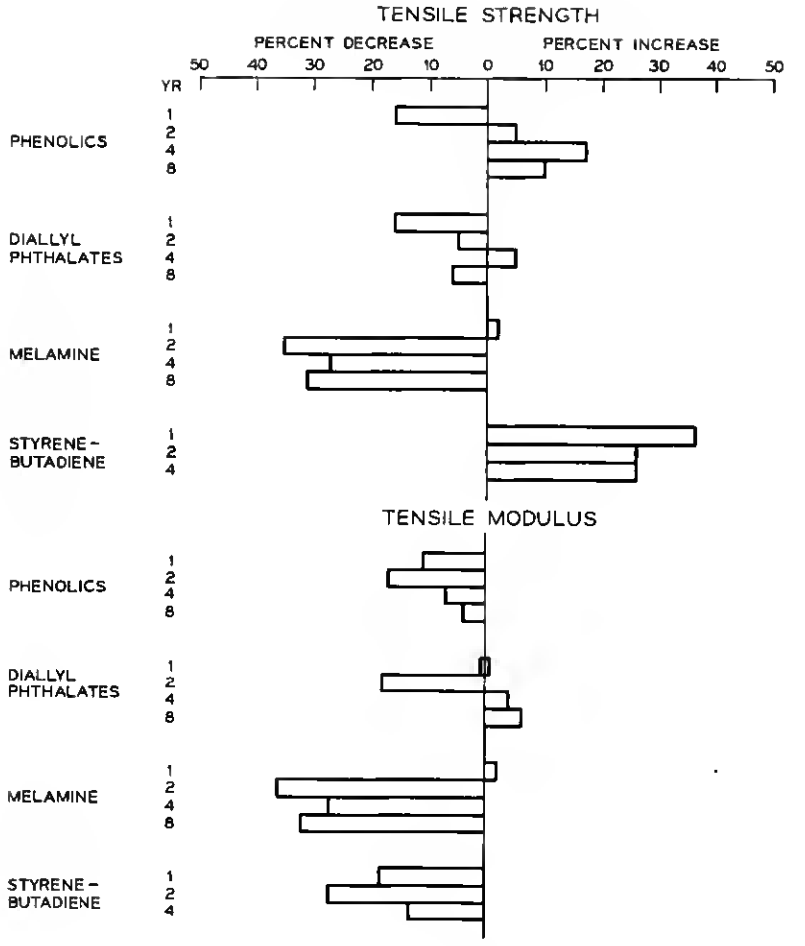

Fig. 4—Changes in tensile properties of thermoset plastics.

has a definite weakening affect on the mechanical properties of phenolic compounds.

The effects of soil burial on all three glass-reinforced thermoset compounds, melamine, styrene-polyester, and alkyd, are generally the same, causing an almost complete deterioration of the mechanical properties. Figures 4, 5, 6, and 7 show there is a significant loss in tensile, flexural, and hardness values for all of these glass-filled compounds.

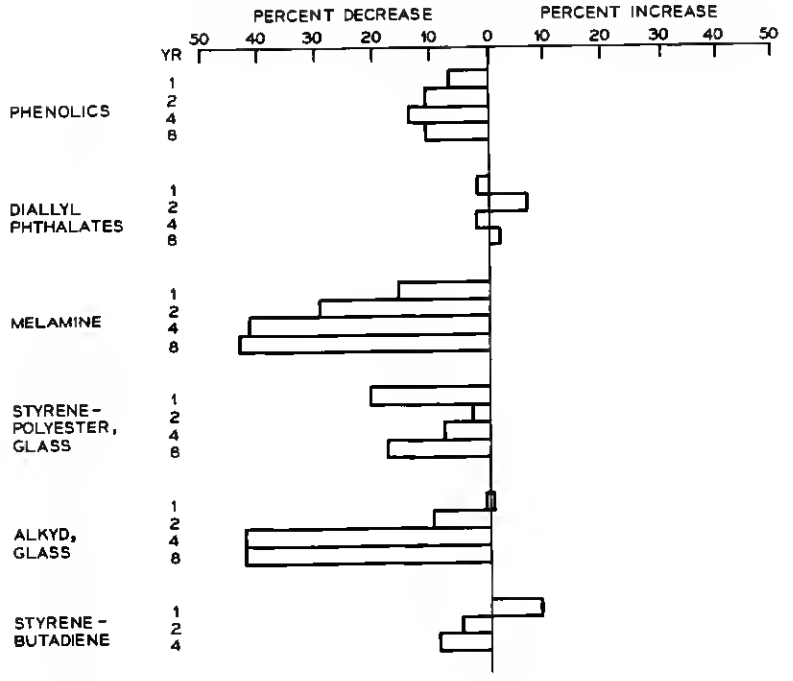

Fig. 5—Changes in flexural strength of thermoset plastics.

4.6 *Insulation Resistance*

The dc insulation resistance of molded plastics after eight years of soil burial in Georgia and New Mexico is given in Table V. These results are not the actual values, but are the orders of magnitude change over the four exposure periods.

The same materials that show the greatest change in mechanical properties, i.e., polyamides, phenolics, melamine, styrene-polyester, alkyd, styrene-butadiene, and cellulosic compounds, also exhibit the largest loss in insulation resistance. Most of these changes are not unexpected. These materials started with relatively low levels of resistance and any surface deterioration would increase their sensitivity to moisture, thereby decreasing the insulation resistance. The styrene and diallyl phthalate molding compounds are reduced 1/2 to 1 order of magnitude. However, their initial values are so high that these changes are not that significant. The remaining plastic materials, all of which started with high insulation resistance, show little or no change after eight years of soil burial.

DISCUSSION OF RESULTS

Many of these changes were physical instead of chemical or biological. The change in mechanical and electrical properties as a result of soil burial was caused mainly by moisture. Many of the plastics tested, such as polyethylene, polystyrene, polypolyamides, poly (vinyl chlorides), and the thermosets, are generally resistant to chemicals that may be found in the soil. This is most likely why soil chemicals played only a minor role in these changes since the results from both Georgia, an acid soil, and New Mexico, an alkaline soil, were similar. The chemical effects will be discussed first.

5.1 *Chemical Changes*

Chemical changes for molded plastics were limited to those materials subject to hydrolysis. The loss of extension in the mechanical properties of nylon 6 is attributed to the moisture content of the soil and the subsequent degradation caused by hydrolysis. The general structure

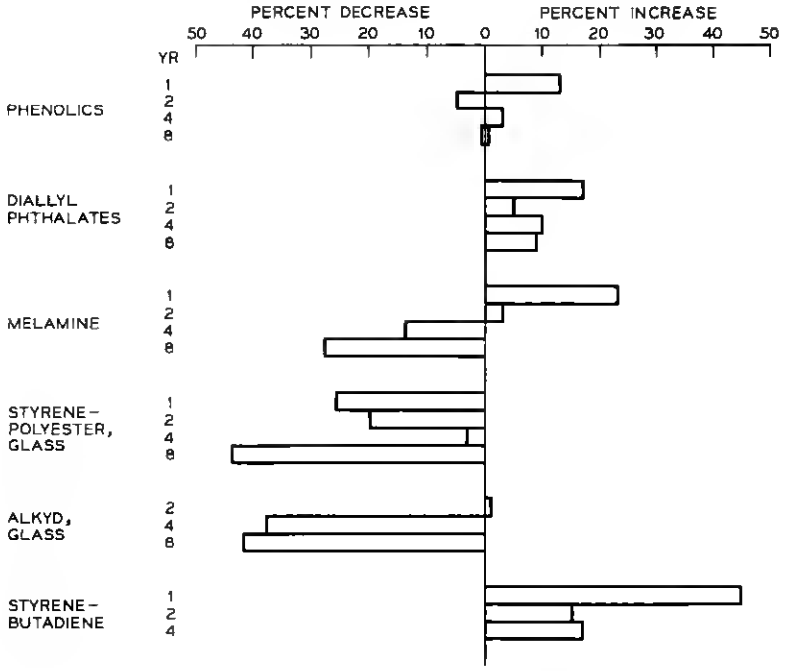

Fig. 6—Changes in flexural modulus of thermoset plastics.

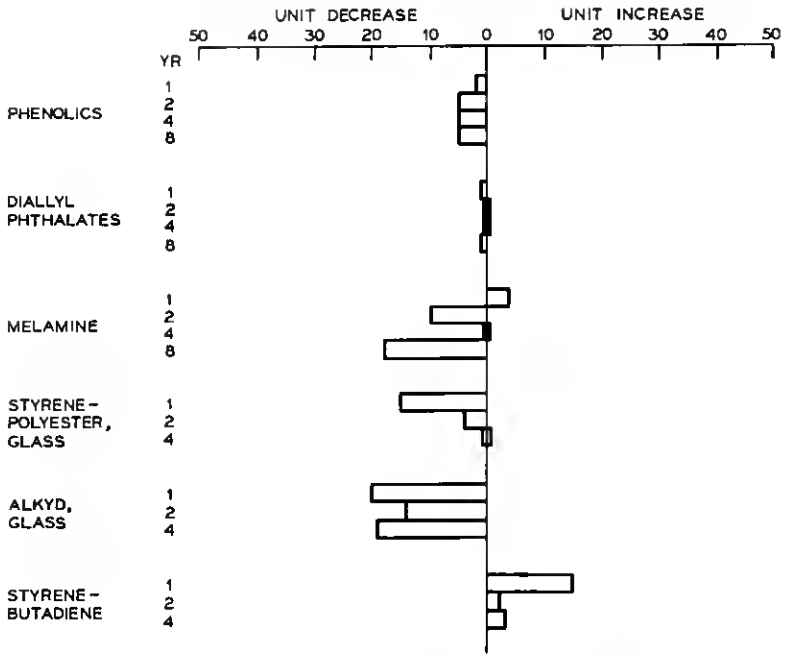

Fig. 7—Changes in hardness for thermoset plastics.

of nylons results from the condensation reaction of an organic acid with an amine.[2] The longer the hydrocarbon part of the chain, for instance, the less the attraction between the chains and therefore the lower the softening point, tensile strength, and stiffness because the hydrogen bonding is, in effect, diluted along the chain. However, the longer hydrocarbon groups are advantageous since they lead to a reduction in water absorption. Type 610 nylon absorbs 75 percent less moisture than nylon 6 and suffers no appreciable loss in mechanical properties due to soil burial.

5.2 *Physical Changes*

Physical changes to molded plastics buried in soil are attributed to loss of plasticizer, moisture absorption, and, in two cases, biological attack.

5.2.1 *Leaching*

Leaching occurs when water removes soluble constituents as they migrate to the surface of the plastic. In most cases this is probably a plasticizer or chemical additive used for some specific purpose. It

is believed that loss of plasticizer in cellulosic compounds is more responsible for the change in tensile properties than the degradation through hydrolysis. The more plasticized cellulose acetate butyrate compounds show more change in these properties than cellulose propionate. No evidence for cellulosic polymer degradation was found by infrared analysis.

The semirigid poly (vinyl chloride) compound contains 43 phr (parts per hundred of resin) of DNODP (di-n-octyl-n-decyl phthalate) plasticizer. In addition to the loss of mechanical properties, semirigid PVC had black greasy surface deposits which were not totally removed by the cleaning method employed. Both of these results suggest that plasticizer is exuding. However, since this compound also contains 10 phr of di-basic lead phosphite (a lead stabilizer) and fatty acid lubricants, these components may be migrating to the surface. The black discoloration could be lead sulfate. As pointed out before, changes in the plasticizer content can have a marked effect on mechanical properties, but there is no evidence that the PVC resin itself has been degraded. Another mechanism for plasticized composition deterioration would be the absorption of the plasticizer by the surrounding dry soil. Since there were no major differences at either the Georgia or New Mexico locations, this mechanism may be more important than leaching.

5.2.2 *Moisture Absorption*

In general, cellulose compounds, polyamides, and those compounds with hydrophilic OH, COOH, or NH groups are sensitive to moisture,

TABLE V—DC INSULATION RESISTANCE

Materials/Exposure Periods	Orders of Magnitude of Change			
	1 Yr	2 Yrs	4 Yrs	8 Yrs
Cellulosics	0	0	2 1/2	1/2
Styrenes	1/2	1 1/2	1/2	1/2
Acrylic	0	0	1	0
Polyolefins	0	0	0	0
Poly (vinyl chloride)	0	0	0	0
Polycarbonate	0	0	0	0
Acetals	0	0	0	0
Fluorocarbon Polymers	0	0	0	0
Polyamides	2	2	2	2
Phenolics	1 1/2	1	1/2	1
Diallyl Phthalates	1	2	1/2	1
Melamine, Glass	3	3	2	3
Styrene-Polyester, Glass	3	3	3	
Alkyd, Glass	2	2	3	
Styrene-Butadiene	3	4	4	

while compounds low in oxygen and nitrogen but rich in carbon, hydrogen, or halogen are moisture resistant.[4] The styrene and acetal group can absorb up to 1 percent moisture at saturation while the polyolefins and fluorocarbon polymers absorb less than 0.1 percent. All of these latter materials are structurally stable compounds in a soil environment.

Wood-flour-filled phenolics would be expected to have greater changes than either mineral- or asbestos-filled formulations since the former can absorb a maximum of 7 to 8 percent of water while the latter equilibrate after absorbing only 1 to 2 percent. Diallyl phthalates show no large change due to the 1 to 2 percent moisture they can absorb.

Although moisture plays an important part in the glass-filled materials' susceptibility to soil burial, the mechanism of water attack is somewhat different from that of the wood-flour-filled phenolics. The melamine, styrene-polyester, and alkyd glass-filled compounds absorb about 1 to 3 percent moisture. However, the effect of soil burial on these compounds has been caused by the erosion of the resin-rich surface of the test specimens leaving the glass fibers close to the outer surface exposed. Whereas the wood-flour fillers actually absorb moisture, water is introduced into the glass-filled material by a "wicking" action at the resin/glass interface. Apparently these materials do not possess an adequate chemical bonding or coupling agent to achieve good adhesion between the glass reinforcement and the resin. The result has been a gradual decrease in the resin/glass bond and a subsequent failure in the material's mechanical properties. It should be pointed out, however, that in recent years significant advances have been made in glass finishes, providing much better adhesion between glass and resin than that available in the compounds studied.

5.2.3 *Biological Attack*

Only two compounds were susceptible to attack by gnawing insects. Both of these were copolymers of polyethylene, ethylene-ethyl acrylate and ethylene-vinyl acetate, and were natural in color. Most of the damage occurred at the edges of the specimen; however, there were some isolated spots throughout the surface of some of the specimens that were eaten away.

5.2.4 *Appearance Changes*

While the functional and structural integrity of a molded plastic buried in a soil environment is of more concern than the aesthetic

value, a change in appearance can sometimes indicate the cause of failure. All of the following changes were noted after the first exposure period, indicating that there is very little induction time and that these changes start to occur almost immediately after soil burial.

The cellulose acetate butyrate and the semirigid poly (vinyl chloride) showed evidence of plasticizer migration on the surface. The cellulosic compounds were covered with a white soapy substance, while the vinyl material had black greasy deposits along its surface. The exuded plasticizer of both of these compounds has apparently reacted with the surrounding soil chemicals or carried some of the other compound ingredients to the surface.

Those compounds that have been stained by the imprints of plant root systems include the cellulosics, type 6 nylon, semirigid poly (vinyl chloride), and the thermoplastic polyurethane molding compound. The glass-filled melamine, styrene-polyester, and alkyd thermoset compounds showed areas of blotchy orange-yellow stains. In addition, erosion of the resin of these materials has left the surfaces extremely rough as a result of the exposed glass fibers.

As far as the other materials are concerned, once the soil is removed from the test specimens using tap water, there is no indication that they have been exposed to soil. Many of the materials still retain their original high gloss.

VI. ENGINEERING IMPLICATIONS

In conclusion, the changes in mechanical and electrical properties of the materials reported on in this paper represent the permanent cumulative damage that has occurred over the past eight years of soil burial. The most significant changes were to those materials most sensitive to the effect of moisture. These include the cellulosic compounds, type 6 nylon, wood-flour-filled phenolics, silica-filled styrene-butadiene resin, and the glass-filled melamine, alkyd, and styrene-polyester compounds. These molded plastics would not be recommended for applications underground.

Most changes were independent of either burial location (Georgia or New Mexico) or depth of soil burial (6 and 18 inches). In general, the effect of soil burial has been mild on most of the other molded plastics which would be suitable for underground plant.

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